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Research Article

EFFICACY OF POST EMERGENCE HERBICIDES ON WEED CONTROL EFFICIENCY, PARTITIONING OF DRYMATTER AND YIELD OF BLACKGRAM (*VIGNA MUNGO* (L.) HEPPER)

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ABSTRACT
The present investigation was undertaken at Agricultural College Farm, Bapatla during *kharif*, 2015. The experiment was laid out in Randomized Block Design with ten treatments replicated thrice. The post emergence herbicides *viz.*, imazethapyr 10% EC @ 50 g a.i ha^{-1} and acifluorfen sodium 16% EC + clodinafop propargyl 8% EC (24% EC) @ 180, 240 and 300 g a.i ha^{-1} were sprayed at 15 and 25 DAS. Hand weeding and weedy check were also included for comparison. Statistical analysis of the data showed that all the parameters were affected by herbicides. Weed free check was found best by recording highest weed control efficiency, plant dry weight, yield parameters and yield of blackgram. It was at par with acifluorfen sodium + clodinafop propargyl @ 300g a.i ha^{-1} at 15 DAS followed by acifluorfen sodium + clodinafop propargyl @ 240g a.i ha^{-1} at 15 DAS. Weed free check and acifluorfen sodium + clodinafop propargyl @ 300 and 240g a.i ha^{-1} at 15 DAS increased the yield attributes and seed yield of blackgram. These three treatments increased the seed yield by 77.6, 69.4 and 67.8 per cent, respectively, over unweeded control. The favourable economic benefit interms of benefit-cost ratio was observed by the application of acifluorfen sodium + clodinafop propargyl @ 240g a.i ha^{-1} at 15 DAS.

Keywords: *Blackgram, Post Emergence Herbicides, Weed Control Efficiency and Yield*

INTRODUCTION
Blackgram [*Vigna mungo* (L.) Hepper)] is an important legume crop cultivated worldwide in tropical and subtropical regions and is valued for high protein in its seeds. India is the largest producer and consumer of blackgram in the world.

It is the fourth important pulse crop in India and second most important in Andhra Pradesh in terms of extent of cultivation.

As a pulse crop, blackgram plays an important role in Indian diet. It contains about 26 per cent protein, 57 per cent carbohydrate and 1.2 per cent fat. It is a good source of phosphoric acid, calcium and vitamins like thiamine (B_1), riboflavin (B_2) and niacin (B_3), grown primarily for its protein rich seeds, used as dhal. The protection of crops from weeds and other vegetation which inhibit crop growth is a constantly recurring problem in agriculture. In blackgram, an average yield reduction of 30-50 per cent has been reported due to weed competition (Mishra, 1997). Controlling the weeds at optimum time is necessary for improving the yield of blackgram. The chemical weed control methods are being easy, economic and time saving process.

The use of herbicides, even in tolerant cultivars, can generate stress conditions, evidenced by the increase in phytotoxicity, which affects growth, development and productivity. The negative effect of stress is often mediated by the oxidative damage initiated by reactive oxygen species (ROS). The herbicides selectivity can be visually assessed by means of the phytotoxicity symptoms in plants, and also by the change in growth and yield parameters.

Recently, some new post emergence herbicides viz., imazethapyr, acifluorfen sodium and clodinafop propargyl *etc*. are being marketed with the assurance of selective control of weeds in blackgram. Although these are recommended for blackgram, there are field reports of phytotoxicity in the crop after the application of imazethapyr, acifluorfen sodium and clodinafop propargyl. Therefore, the present investigation was undertaken to study the efficacy of post emergence herbicides on weed control efficiency, partitioning of drymatter and yield of blackgram.

MATERIALS AND METHODS

The field experiment was conducted at northern block of Agricultural College Farm, Bapatla, on a sandy clay loam soil in *Kharif*, 2015. The experiment was laid out in a Randomized Block Design with three replications. The crop was fertilized with nitrogen and phosphorus @ 20 kg N ha^{-1} in the form of urea and 50 kg P_2O_5 ha^{-1} in the form of single super phosphate before sowing of crop. The post emergence herbicides *viz*., imazethapyr 10% EC @ 50 g a.i ha^{-1} and acifluorfen sodium 16% EC + clodinafop propargyl 8% EC (24% EC) @ 180, 240 and 300 g a.i ha^{-1} were sprayed at 15 and 25 DAS using knapsack sprayer fitted with flat fan nozzle at spray volume of 500 L ha^{-1}.

The observations on weed control efficiency were recorded at 60 DAS. Partitioning of dry matter and yield parameters like number of pods per plant, number of seeds per pod, pod weight per plant, 100 seed weight and yield were taken at harvest.

RESULTS AND DISCUSSION

Weed Control Efficiency (WCE)

The data pertaining to weed control efficiency of different treatments are furnished in Table 1. The highest weed control efficiency was noticed with two hand weedings treatment (83.0%). Among the different herbicides, post emergence application of acifluorfen sodium + clodinafop propargyl at 300 and 240g a.i ha^{-1} sprayed at 15 DAS registered higher weed control efficiency (70.6 and 68.0%) respectively. This was due to greater reduction in weed biomass in these treatments which might have increased the weed control efficiency. Imazethapyr at 50g ha^{-1} at 15 and 25 DAS recorded lower weed control efficiency (50.5 and 41.6%), respectively over high doses of acifluorfen sodium + clodinafop propargyl. Such variations in the efficiency of different herbicides were because of their chemical structure and mode of action (Vyas and Jain, 2003; Kalpana and Velayutham, 2004). From the study, it is clear that the combined use of acifluorfen sodium 16% EC plus clodinafop propargyl 8% EC (24% EC) @ 300g a.i ha^{-1} at 15 DAS was found superior to its other doses of 240 and 180g a.i ha^{-1} in weed control efficiency.

Partitioning of Dry Matter (g $Plant^{-1}$)

Leaf Dry Matter

The data on leaf dry matter as affected by post emergence herbicides at 60 DAS was furnished in Table 1. At 60 DAS, post emergence application of acifluorfen sodium 16% EC + clodinafop propargyl 8% EC (24%EC) @ 300g a.i ha^{-1} at 15DAS (T_7) and weed free treatment (T_9) recorded higher leaf dry matter (7.12 g $plant^{-1}$) which were on par with all other herbicide treatments except imazethapyr 10% EC @ 50g a.i ha^{-1} at 25DAS (T_2) and acifluorfen sodium + clodinafop propargyl @ 300g a.i ha^{-1} at 25DAS (T_8). Lower leaf dry matter was recorded in unweeded control (T_{10}) *i.e.* 5.37 g $plant^{-1}$ which was on a par with the treatments T_2 and T_8.

In the present study, post emergence application of acifluorfen sodium 16% EC + clodinafop propargyl 8% EC (24%EC) @ 300, 240g a.i ha^{-1} at 15DAS (T_7 and T_5) and weed free treatment (T_9-hand weeding at 15 and 30 DAS) exhibited better performance in increasing leaf dry matter by 32.6, 32.0 and 32.6 per cent respectively, over unweeded control at 60DAS. Other treatments increased the leaf dry matter in the range between 9.3 to 28.5 per cent. So, considering economic benefit, it is better to go for post emergence application of acifluorfen sodium + clodinafop propargyl @ 240 and 300g a.i ha^{-1} at 15DAS to increase leaf dry matter through effective removal of weeds during the critical period of crop weed competition in blackgram.

Stem Dry Matter (g $Plant^{-1}$)

The stem dry matter as affected by post emergence herbicides at harvest presented in Table 1. At harvest, higher stem dry matter was obtained in hand weeding treatment at 15 and 30 DAS *i.e.* T_9 (7.18 g $plant^{-1}$) followed by T_7 (7.05 g $plant^{-1}$) and T_5 (6.94 g $plant^{-1}$). Significantly lesser dry matter was observed in un weeded control (T_{10}-4.08 g $plant^{-1}$) than other treatments.

In the present study, weed free check (T_9) and post emergence application of acifluorfen sodium + clodinafop propargyl @ 300g a.i ha^{-1} (T_7) and 240 g a.i ha^{-1} (T_5) at 15DAS increased the stem dry matter by 3.10, 2.97 and 2.86g over un weeded control at harvest.

Reproductive Parts Dry Matter (g Plant^{-1})

The data on dry weight of reproductive parts as affected by post emergence herbicide sprays at harvest are presented in Table 1. At harvest, higher reproductive parts dry matter was recorded in weed free treatment i.e.T_9 (5.08 g plant^{-1}) which was on a par with T_7 (5.04 g plant^{-1}), T_5 (4.98 g plant^{-1}) and T_1 (4.62 g plant^{-1}). The remaining treatments were on par with each other and significantly higher over unweeded control, except acifluorfen sodium + clodinafop propargyl @ 300 g a.i ha^{-1} at 25DAS, which was at par with control (T_{10}). Lower value was recorded in control treatment (T_{10}-3.56g plant^{-1}).

From the data, it is evident that post emergence application of acifluorfen sodium + clodinafop propargyl @ 240, 300g a.i ha^{-1} sprayed at 15 DAS and weed free check increased the dry matter of reproductive parts by 40.0, 41.6 and 42.7 per cent, respectively over un weeded control at harvest.

Total Dry Matter (g Plant^{-1})

Total dry matter production and its partitioning are the key factors in determining the economic yield of the crop. Weed free check (T_9) registered higher amount of total dry matter (18.16 g plant^{-1}) which was statistically at par with T_7 (17.96g plant^{-1}) and T_5 (17.53g plant^{-1}), and significantly superior over control and other treatments. Unweeded control accumulated lesser dry matter (11.65 g plant^{-1}) due to severe weed competition. All other treatments were significantly higher over control.

In the present study, two hand weedings at 15 and 30 DAS (weed free check) and post emergence application of acifluorfen sodium + clodinafop propargyl @ 300 and 240g a.i ha^{-1} at 15DAS increased the total dry matter of blackgram by 55.9, 54.2 and 50.5 per cent, respectively, over un weeded control because of better weed control. This better weed control resulted in favourable environment to have higher nutrient uptake reflected on higher leaf area index and better source sink relationship for accumulating higher dry matter.

On the other hand, unweeded control recorded lower total dry matter due to severe weed competition at all stages of crop growth. Whereas imazethapyr @ 50 g a.i ha^{-1} at 15 and 25 DAS increased the total dry matter of blackgram by 33.5 and 25.7 per cent, respectively, over un weeded control and decreased the total dry matter by 15.5 and 22.7 per cent, respectively, over higher doses of acifluorfen sodium + clodinafop propargyl i.e. 300g a.i ha^{-1} at 15 DAS.

This is due to lower dose of imazethapyr (i.e. 50 g ha^{-1}) at 15 and 25 DAS could not able to control the weed population, which resulted in higher weed dry matter in these plots and ultimately recorded lesser dry matter of blackgram.

The above results were in tune with research findings of Jha *et al*., (2012) in soybean crop. He reported that weed free check produced significantly higher plant dry weight of 17.46g plant^{-1} over weedy check (5.53g plant^{-1}) and combined use of clodinafop propargyl 8% EC + Na-acifluorfen 16.5 SL @ 100 + 206.2 g a.i ha^{-1} recorded significantly more plant dry weight. Such beneficial effects of herbicides on plant dry weight may be due to effective weed control and minimizing the crop weed competition resulting in better plant growth (Chandel and Saxena, 2001). Rao (2005) also reported that post emergence application of clodinafop propargyl @ 53g ha^{-1} applied at 14 DAS recorded higher dry weight of rice seedlings at 30 DAS.

It is evident from the present study that post emergence application of acifluorfen sodium 16 % EC + clodinafop propargyl 8 % EC (24 % EC) @ 240 and 300 g a.i ha^{-1} at 15 DAS were found superior by maintaining higher leaf area and biomass production through effective weed control in blackgram. Hand weeding twice at 15 and 30 DAS also recorded similar performance with the above herbicide sprays.

Yield Attributes and Yield

Different weed control treatments increased the number of pods per plant from 2.7 to 65.9 per cent compared to weedy check (Table 2). Weed free check and post emergence application of acifluorfen sodium + clodinafop propargyl @ 300 and 240 g a.i ha^{-1} at 15 DAS increased the pods per plant by 65.9, 58.8 and 52.7 per cent, respectively, over unweeded control.

The highest number of seeds per pod (5.2) was recorded under hand weeding twice at 15 and 30 DAS, followed by post emergence application of acifluorfen sodium + clodinafop propargyl @ 300 (4.9) and 240 (4.8) g a.i ha^{-1} at 15 DAS.

Table 1: Effect of Post Emergence Herbicides on Weed Control Efficiency and Partitioning of Dry Matter of Blackgram

Treatments	Weed Control Efficiency (%)	Leaf Dry Matter (g Plant^{-1})	Stem Dry Matter (g Plant^{-1})	Reproductive Parts Dry Matter (g Plant^{-1})	Total Dry Matter (g Plant^{-1})
T1 Imazethapyr 10% EC @ 50g a.i ha^{-1} at 15 DAS	50.48	6.43	5.84	4.62	15.55
T2 Imazethapyr 10% EC @ 50g a.i ha^{-1} at 25 DAS	41.56	5.97	5.41	4.24	14.64
T3 Acifluorfen Sodium 16%EC + Clodinafop propargyl 8%EC (24%EC)@180g a.i ha^{-1} at 15DAS	49.41	6.41	6.09	4.38	15.28
T4 Acifluorfen Sodium 16%EC + Clodinafop propargyl 8%EC (24%EC)@180 g a.i ha^{-1} at 25DAS	48.93	6.09	6.05	4.03	14.82
T5 Acifluorfen Sodium 16%EC + Clodinafop propargyl 8%EC (24%EC)@240g a.i ha^{-1} at 15DAS	67.96	7.09	6.94	4.98	17.53
T6 Acifluorfen Sodium 16%EC + Clodinafop propargyl 8%EC(24%EC)@240g a.i ha^{-1} at 25DAS	51.10	6.90	6.26	4.28	15.22
T7 Acifluorfen Sodium 16%EC + Clodinafop propargyl 8%EC (24%EC)@300g a.i ha^{-1} at 15DAS	70.63	7.12	7.05	5.04	17.96
T8 Acifluorfen Sodium 16%EC + Clodinafop propargyl 8%EC(24%EC)@300g a.i ha^{-1} at 25DAS	48.51	5.87	5.90	4.38	14.38
T9 Weed free check (Hand weeding at 15and 30 DAS)	82.96	7.12	7.18	5.08	18.16
T10 Un weeded control	0	5.37	4.08	3.56	11.65
SEm+	1.72	0.370	0.277	0.212	0.769
CD	5.20	1.098	0.824	0.629	2.286
CV (%)	7.80	10.1	8.1	8.4	8.8

Table 2: Effect of Post Emergence Herbicides on Yield Components, Yield and Economics of Blackgram

Treatments	No. of Pods Plant^{-1}	No. of Seeds Pod^{-1}	Pod Weight (g plant^{-1})	100 Seed Weight (g)	Seed Yield (kg ha^{-1})	B:C Ratio
T1 Imazethapyr 10% EC@50g a.i ha^{-1} at 15 DAS	23.4	3.4	15.55	3.81	740.74	1.04
T2 Imazethapyr 10% EC@50g a.i ha^{-1} at 25 DAS	19.2	3.5	14.64	3.95	768.25	1.12
T3 Acifluorfen Sodium 16%EC + Clodinafop propargyl 8%EC (24%EC)@180g a.i ha^{-1} at 15DAS	25.6	4.2	15.28	4.34	771.60	1.08
T4 Acifluorfen Sodium 16%EC + Clodinafop propargyl 8%EC (24%EC)@180 g a.i ha^{-1} at 25DAS	18.7	4.4	14.82	4.23	632.09	0.70
T5 Acifluorfen Sodium 16%EC + Clodinafop propargyl 8%EC (24%EC)@240g a.i ha^{-1} at 15DAS	27.8	4.8	17.53	4.51	987.60	1.59
T6 Acifluorfen Sodium 16%EC + Clodinafop propargyl 8%EC(24%EC)@240g a.i ha^{-1} at 25DAS	24.6	4.3	15.22	4.18	925.90	1.43
T7 Acifluorfen Sodium 16%EC + Clodinafop propargyl 8%EC (24%EC)@300g a.i ha^{-1} at 15DAS	28.9	4.9	17.96	4.92	1001.60	1.56
T8 Acifluorfen Sodium 16%EC + Clodinafop propargyl 8%EC(24%EC)@300g a.i ha^{-1} at 25DAS	23.4	4.1	14.38	4.53	655.50	0.68
T9 Weed free check (Hand weeding at 15and 30 DAS)	30.2	5.2	18.16	4.92	1050.20	1.37
T10 Un weeded control	18.2	3.0	11.65	3.59	591.23	0.73
SEm+	0.5	0.04	0.769	0.02	41.13	
CD	1.5	0.12	2.286	0.06	123.4	
CV (%)	2.8	2.05	8.8	1.01	11.6	

Post emergence application of acifluorfen sodium 16% EC + clodinafop propargyl 8% EC (24% EC) @ 240, 300 g a.i ha^{-1} at 15 DAS and weed free treatment increased the pod weight by 40.0, 41.6 and 42.6 per cent, respectively, over unweeded control. There was a significant increase in 100 seed weight (test weight) due to weed control treatments. The maximum 100- seed weight observed was 4.92g versus control (3.50g) as a result of combined application of acifluorfen sodium + clodinafop propargyl @ 300 g a.i ha^{-1} at 15 DAS and this treatment is at par with weed free check (4.92 g) and superior over other herbicidal treatments. These two treatments increased the 100- seed weight by 37 per cent over unweeded control.

The highest seed yield was recorded with weed free check (T_9 –1050.20 kg ha^{-1}), where yield attributes were also higher. Among different herbicides, post emergence application of acifluorfen sodium 16% EC + clodinafop propargyl 8% EC (24% EC) @ 300g a.i ha^{-1} at 15 DAS recorded higher seed yield (T_7 – 1001.60 kg ha^{-1}) which was statistically at par to its 240g ha^{-1} at 15 DAS (T_5 – 987.60kg ha^{-1}) due to better yield attributes. These two treatments were at par with weed free check. This significant increase in yield due to these treatments may be because of reduced crop-weed competition at critical stages as reflected by significantly low weed population and dry matter, resulting in better accumulation of photosynthtes. Remaining herbicidal treatments (i.e. T_1, T_2, T_3, and T_6) were significantly superior over unweeded control. Weedy check (T_{10}) recorded lowest seed yield (591.23 kg ha^{-1}) due to heavy infestation of weeds. All the weed control treatments increased the seed yield of blackgram by 6.9 to 77.6 per cent over weedy check (Table 2). Weed free check and post emergence application of acifluorfen sodium 16% EC + clodinafop propargyl 8% EC (24% EC) @ 300 and 240 g a.i ha^{-1} at 15 DAS increased the seed yield by 77.6, 69.4 and 67.8 per cent, respectively, over unweeded control. Though, imazethapyr @ 50 g ha^{-1} at 15 and 25 DAS recorded significant increase in yield (25.3 and 29.9 per cent, respectively) over unweeded control, but these two treatments were inferior over the combined use of acifluorfen sodium + clodinafop propargyl at 240 and 300g a.i ha^{-1} at 15 DAS.

Economics

The highest benefit cost ratio was recorded with acifluorfen sodium + clodinafop propargyl @ 240g a.i ha^{-1} (i.e. 1.59) and this was closely followed by acifluorfen sodium + clodinafop propargyl @ 300g a.i ha^{-1} (i.e. 1.56) and hand weeding at 15 and 30 DAS with 1.37 indicating the cost effectiveness of herbicides, whereas weed free treatment involved highest labour cost and cost of cultivation, which leads decreased net returns.

Conclusion

From this study, it can be concluded that post emergence application of acifluorfen sodium + clodinafop propargyl @ 240g a.i ha^{-1} at 15 DAS is recommended for weed control in blackgram as it improved the growth, dry matter production and yield of blackgram through better weed control efficiency.

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